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A Revision of the Surgeon Fish Genus *Ctenochaetus*, Family Acanthuridae, with Descriptions of Five New Species[1]

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(Plates I & II; Text-figures 1-3)

THE genus *Ctenochaetus* is distinguished from other surgeon fish genera chiefly by its unique teeth, which are numerous, loosely attached in the jaws and very elongate, with expanded incurved tips. Little difficulty is experienced in assigning specimens to this genus; however, insufficient attention has been given to identification at the species level. Two specific names, *striatus* Quoy & Gaimard and *strigosus* Bennett, have been applied indiscriminately. Generally only one or the other name is used and some authors have asserted their belief that the genus is monotypic. In this paper the validity of *C. striatus* and *C. strigosus* is established and five other species are described as new.

Several species of *Ctenochaetus* are very abundant in the tropical inshore waters of the Pacific and Indian Oceans and the genus is extensively recorded in the literature. Many records are listings of names only and others contain too little descriptive information to provide identification. Such records have been omitted, generally, unless the specimens reported on were examined by me.

Drawings of adults of only two of the seven species are given. The others have either been pictured previously or present insufficient differences in external appearance from remaining species to warrant the preparation of figures. The shape of the teeth (principally the number of denticulations on the lateral edge of the expanded tips) has been found to be the most important basis for the separation of species. Text-fig. 1 consists of drawings of the teeth of all seven species. The number of teeth (Text-fig. 2) and fin ray and gill raker counts (Tables 1-3) are also of diagnostic value.

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The types of the new species are deposited in the United States National Museum.

METHODS OF COUNTING AND MEASURING

Each ray of the dorsal and anal fins with a distinct base was counted regardless of how close adjacent rays might be. In cases where two rays branch from a common base, they were counted as one. At times dissection was necessary to determine whether the last two rays originate from a single basal element. Pectoral fin ray counts include the two uppermost unbranched rays, the first being a very short bony spicule. Few gill raker counts were made, because it is difficult to remove a complete gill arch from an acanthurid without damaging the specimen. The gill rakers are small and occur in two distinct series, anterior and posterior (actually more medial on the arch than posterior). All rakers (including rudiments) in each series were counted separately. In many instances it was not possible to determine which raker occupied the position at the angle of the arch, therefore

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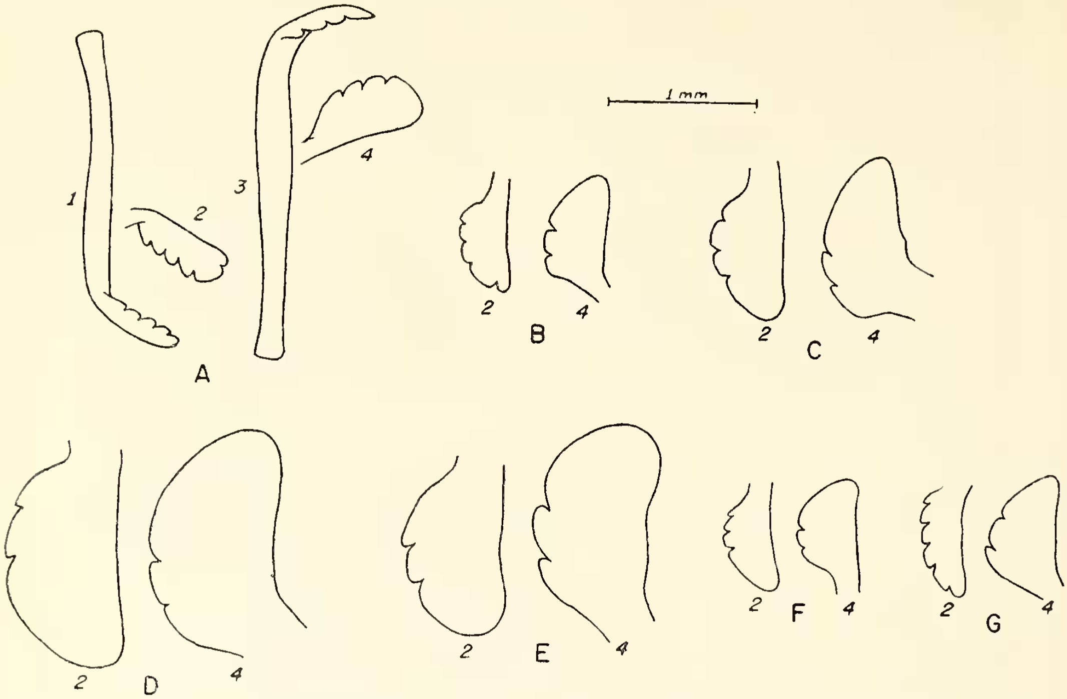


Text-fig. 1. Camera lucida drawings of the teeth of *Ctenochaetus*. A. *striatus*, 141 mm. specimen, Marshall Islands. B. *strigosus*, 119 mm. specimen, Hawaiian Islands. C. *cyanoguttatus*, type. D. *hawaiiensis*, type. E. *magnus*, type. F. *tominiensis*, type. G. *binotatus*, type. 1. lateral view of upper tooth. 2. inner view of end of upper tooth. 3. lateral view of lower tooth. 4. inner view of end of lower tooth. All of the teeth were taken from the left side of the jaw near the center of the mouth.

only the total count is recorded. Occasional specimens showed a fusion of rakers on the dorsal end of the medial series where the rakers normally become broad, low ridges; no counts from such specimens are included in the table. At least for *C. striatus*, no obvious increase in gill raker counts occurs with increasing size after the fish have completely transformed from the late postlarval or acronurus stage. The state of being completely transformed is easily distinguished by the presence of fully formed scales on the body.

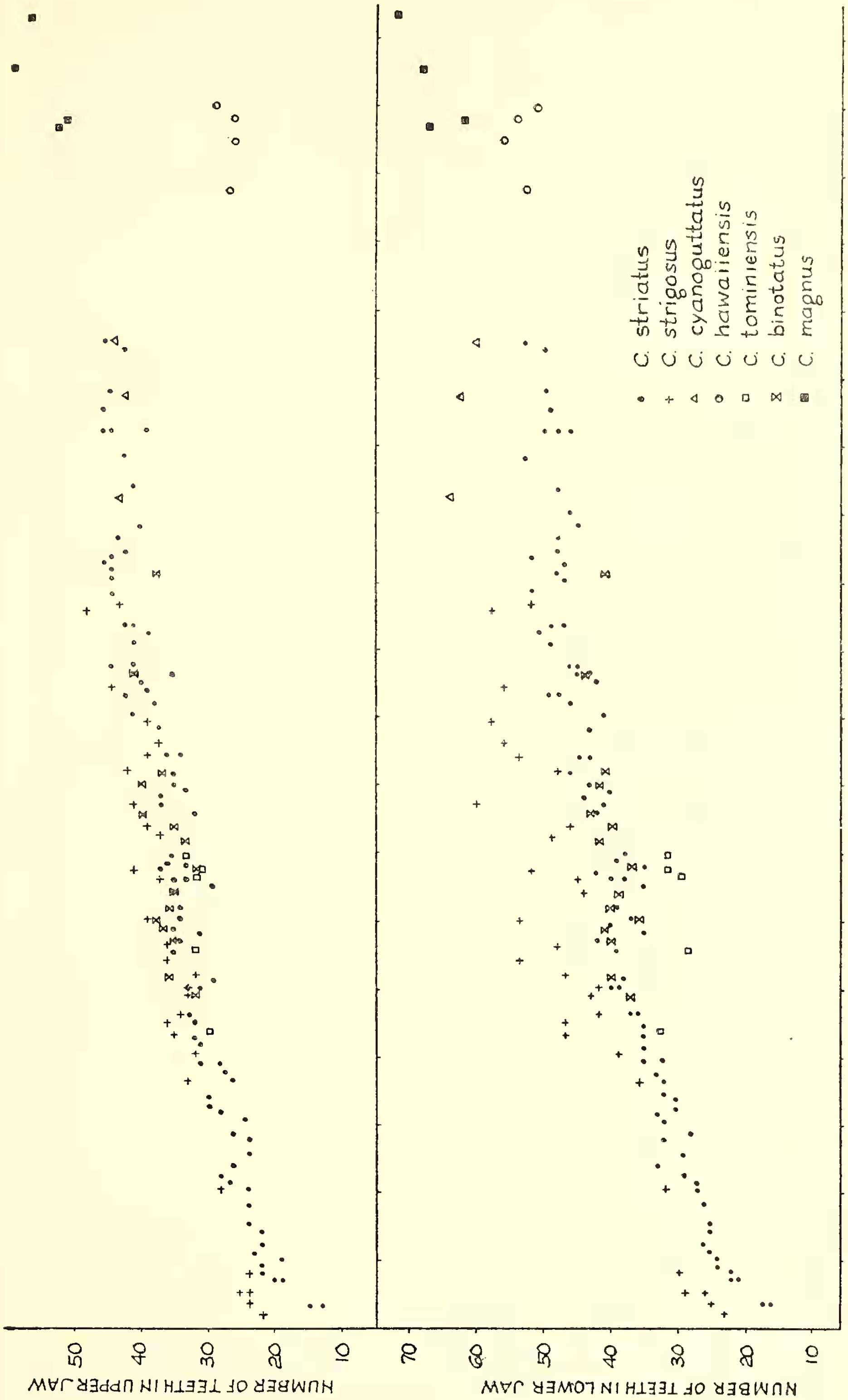
The standard length was measured from the tip of the snout to the posterior end of the hypural plate. Head length was taken from the tip of the snout to the most posterior part of the opercular membrane. Body depth is the distance from the natural groove at the base of the second anal spine to a similar groove at the base of the dorsal fin. Caudal concavity is the distance between vertical lines passing through the tips of the shortest middle caudal ray and the longest ray of the dorsal lobe of the caudal fin. Proportional measurements are based on specimens above 70 mm. in standard length.

Counts of the number of teeth were not made in specimens with tightly closed or damaged jaws. Even the best specimens generally had missing teeth; however, these were detected by empty sockets in the gums and by gaps in the series and were included in the total counts.

The number of teeth was found to increase with increasing size in *striatus* and *strigosus*. Text-fig. 2 represents a graph of the relationship between the number of teeth and the standard length of these two species. Such data from the available specimens of the other five species are also included in the graph, but there are not enough of these of different lengths to clearly show this relationship.

Scale counts are difficult to make, for the scales are small and not in even rows. Approximate scale counts are recorded as the number of vertical scale rows from the upper end of the gill opening to the posterior end of the caudal peduncle spine.

In the description of new species, data in parentheses are referable to paratypes. Proportional measurements and counts of scales were made on five paratypes, if available, including the largest and smallest specimens. Fin ray counts are based on all paratypes. Tooth counts



TEXT-FIG. 2. Tooth counts of *Ctenochaetus.*

and gill raker counts of paratypes may be found in Text-fig. 2 and Table 3, respectively.

Genus CTENOCHAETUS Gill

Ctenodon Klunzinger, Synopsis der Fische des Rothen Meers, 1870: 509 (proposed as a subgenus; preoccupied by *Ctenodon* Wagler 1830).

Ctenochaetus Gill, Proc. U. S. Nat. Mus., **7**: 279. 1885 (Type species, *Acanthurus strigosus* Bennett).

Quoy & Gaimard (1824) described and figured the first species of this genus as *Acanthurus striatus*. They remarked on its unusual dentition. E. T. Bennett (1828) named another, *Acanthurus strigosus*, from Hawaii, and he accurately described the teeth. Although Günther (1861) separated two of the species, *strigosus* and *ctenodon* Cuvier & Valenciennes, in a key on the basis of dentition, he left them in *Acanthurus*. Gill (1884) established the genus *Ctenochaetus*, designating *A. strigosus* Bennett

TABLE 1. COUNTS OF THE SOFT RAYS OF THE DORSAL AND ANAL FINS FOR SPECIES OF *Ctenochaetus*

Species and locality	Dorsal soft rays								Anal soft rays							
	24	25	26	27	28	29	30	31	21	22	23	24	25	26	27	28
striatus																
Wake I.					3	6	4						2	6	4	1
Marshall Is.				1	14	39	8					1	3	34	23	1
Gilbert Is.				1	9	13	4	1				1	5	21	1	
Line Is.					2	1	1						1	2	1	
Phoenix Is.					2	2	1						1	3	1	
Samoa Is.					4	9	1	1						7	7	1
Tuamotu Arch.						2	7	2						6	5	
Society Is.						3	4						1	1	5	
Austral Is.							1								1	
Solomon Is.					2	1								3		
New Hebrides					1	1								1	1	
Palau Is.					1	1								1	1	
Mariana Is.					5	8	11	4					1	5	16	6
Philippine Is.				12	24	14						3	23	22	2	
Formosa					2									2		
East Indies				2	2	3							2	4	1	
Egypt, Red Sea					3	2							4		1	
Mauritius				2	2	2	1						3	2	2	
Madagascar							1								1	
strigosus																
Hawaiian Is.		4	19	23	1						9	32	6			
Johnston I.			8	1							2	6	1			
Tuamotu Arch.			4						1	1	1	1				
Philippine Is. & East Indies		3	6	4							7	6				
Mauritius			1								1					
cyanoguttatus, sp. nov.																
Gilbert Is.				2									2			
Phoenix Is.					1								1			
Cocos I.					1								1			
hawaiiensis, sp. nov.																
Hawaii				1	3								3	1		
magnus, sp. nov.																
Malden & Jarvis I.				3								2	1			
Cocos I.			1									1				
tominiensis, sp. nov.																
Celebes	1	5								4	2					
binotatus, sp. nov.																
Philippine Is. & Molucca Is.	2	4	16	8						1	9	17	3			

TABLE 2. COUNTS OF PECTORAL FIN RAYS FOR THE SPECIES OF *Ctenochaetus*

Species and locality	Pectoral fin rays 15	16	17
striatus			
Marshall, Mariana, and Samoa Is.		6	29
Philippine Is. and East Indies		15	24
Egypt, Red Sea		3	4
Mauritius		3	1
strigosus			
Hawaiian Is.	1	22	
Philippine Is.		13	
Mauritius		1	
cyanoguttatus, sp. nov.			
Gilbert, Phoenix, and Cocos Is.		1	3
hawaiiensis, sp. nov.			
Hawaii		4	
magnus, sp. nov.			
Malden, Jarvis, and Cocos I.		1	3
tominiensis, sp. nov.			
Celebes	2	4	
binotatus, sp. nov.			
Philippine and Molucca Is.	3	27	

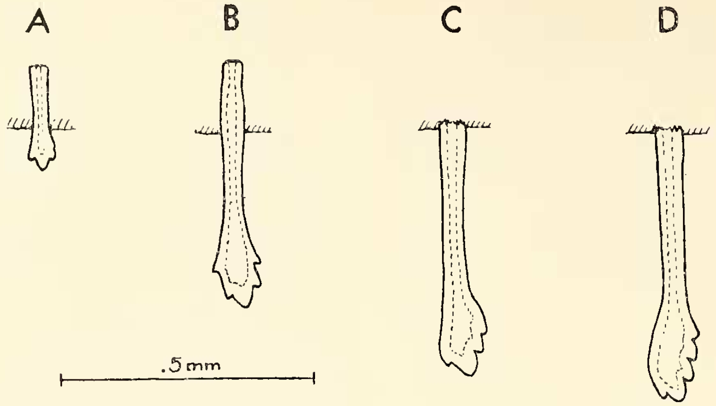
as the type species. He was apparently unaware of *A. striatus* Quoy & Gaimard. Prior to Gill, Klunzinger (1870) set up *Ctenodon* as a subgenus for *strigosus* and *ctenodon*. This was not the *Ctenodon* of Swainson (1839), the type species of which was *Acanthurus sohal* (Forskål), and possibly not of Bonaparte (1833) (for which there was no description nor type specified). However, Wagler's use in 1830 of *Ctenodon* for a reptile invalidates subsequent generic use of this name.

Ctenochaetus is characterized as follows: body compressed, elliptical, the depth contained 1.7 to 2.2 in standard length; head length 3 to 3.8 in standard length; caudal peduncle armed on each side by a single, sharp, folding spine; length of caudal peduncle spine 2.3 to 4.3 in head length; least depth of caudal peduncle 1.9 to 2.7 in head length; mouth small, terminal, and only slightly protractile; jaws equal; teeth numerous, in a single series in each jaw, movable, elongate, with tips expanded, incurved, and denticulate on the lateral margin; eye diameter contained about 3 to 5 times in head length; interorbital space 2.6 to 3.3 in length of head; gill openings restricted to the sides; gill membranes confluent and attached to the isthmus; scales ctenoid, very small, and not in regular rows; head scaled, though not conspicuously; lateral line complete; dorsal fin single, continuous, unnotched, with 8 spines, the first small and easily overlooked; dorsal soft rays 24 to 31; anal fin with 3 spines, the first very short, and 21 to 28 soft rays; the first 2 to 6 dorsal and anal soft rays unbranched; pectoral fins long, their length contained 2.7 to 3.2 in standard length; pectoral rays 15 to 17; pelvic fins I, 5, relatively long and pointed, and only slightly posterior in their insertion to the base of the pectoral fins; caudal fin with 16 principal rays and varying in shape from lunate to nearly truncate; 22 vertebrae; stomach subspherical to oval with very thick walls.

The single erectile spine on each side of the caudal peduncle is a prominent feature of four of the acanthurid genera, *Acanthurus, Ctenochaetus, Paracanthurus* and *Zebrasoma*. The latter genus differs from the other three in having 4 or 5 dorsal spines instead of 7 to 9. The monotypic *Paracanthurus* is readily separable with its pelvic count of I, 3 and its remarkable coloration. *Ctenochaetus*, as noted, is distinguished primarily by its unusual dentition. Usually the genus has 8 dorsal spines (in counts of over 300 specimens two had 9 and three had 7 dorsal spines). In the 28 species of Indo-Pacific *Acanthurus* the usual count of dorsal spines is 9. Two species, *A. pyroferus* Kittlitz and *A. sohal* (Forskål), have 8 and another, *A. nubilus* (Fowler & Bean), has 6 or 7.

Ctenochaetus striatus and certain other species of this genus are similar in general body shape and color pattern to *Acanthurus nigroris* Cuvier & Valenciennes (=*Hepatus atramentatus* Jordan & Evermann, 1905, and *Acanthurus lineolatus* Günther, 1873). The similarity may be seen even in the transforming acronurus stages of these fishes by comparing Fig. A (*C. striatus*) and Fig. C (*A. nigroris*) in Plate 62 of Schultz & Woods (1953). Other *Acanthurus* species such as *lineatus* and *sohal* may be striped in the postacronurus form, but the stripes do not angle downwards as they pass posteriorly on the body. Inconsistent with the apparent close relationship of *Ctenochaetus* to *A. nigroris* is the finding that the roundish, heavy-walled stomach of the former does not resemble the elongate, thin-walled stomach of *A. nigroris* but rather that of such acanthurids as *A. olivaceus* and *A. gahhm*.

Although no existing *Acanthurus* species may be considered the direct progenitor of the genus *Ctenochaetus*, it seems reasonable to conclude (as has Aoyagi, 1943) that *Ctenochaetus* was derived from *Acanthurus*-like stock. This view is supported by the fact that postlarval *Ctenochaetus* have teeth much like those of postlarval *Acanthurus*, and these transform into the typical adult *Ctenochaetus* dentition (see Text-fig. 3 and discussion under *striatus*).



Text-fig. 3. **A.** Upper tooth of 27 mm. acronurus larva of *Ctenochaetus strigosus*. **B** to **D.** Upper teeth from 31 mm. postacronurus stage of *Ctenochaetus striatus*. Dotted lines indicate margins of pulp cavity.

The food habits and method of feeding of *Ctenochaetus strigosus* were investigated. The stomach contents of seven adult specimens from different localities in the Hawaiian Islands were analyzed. All but one fish contained a very large amount (up to 90%) of fine inorganic sediment; the remaining detrital material was mostly algal, consisting of diatoms and small fragments of many kinds of red, green and blue-green algae. About 1 to 2 per cent was soft, unidentifiable organic matter. There were occasional tiny molluscs and crustaceans, sponge spicules, holothurian plates, pedicellaria fragments, etc. The stomach of one specimen was filled primarily with a fine red alga (*Ceramium* sp.), though there was still a large amount of sediment. When a thallus of fine filamentous red algae (*Polysiphonia* sp.) was placed in an aquarium containing two adult specimens of *strigosus,* the fish attempted to feed upon it. Their slender movable teeth, not able to effectively bite off pieces, soon became tangled in the algae, resulting in very little being ingested. When fine particles of the alga were put in the tank and allowed to settle, the fish fed in the following manner: the body was elevated to a near-vertical position about 15 mm. above the bottom, there was a pause, then the fish pecked at a small area, the teeth and lips scraping over the surface. Such an area was not only cleaned of particulate algae but also of very fine sediment that had collected there, suggesting that a suction mechanism is involved as well as a scraping one. There was definitely no lateral plowing or sieving action by the teeth as their comb-like structure might suggest. Sand on the bottom was generally avoided, but if picked up, most was usually forcefully ejected.

Key to the Species of Ctenochaetus

1a. No prominent blackish spot at base of last 3 to 7 rays of both the dorsal and anal fins. (Juvenile and young adult *striatus* have a small black spot basally at rear of dorsal fin only).

  2a. Teeth of the upper jaw with 4 to 7 denticulations (including tip) on lateral edge of their distal expanded ends.

    3a. Teeth of the upper jaw with 5 to 7 denticulations on lateral edge of their distal expanded ends; body with numerous pale longitudinal stripes (often faint or not visible in preserved specimens); spots, if present, occur only on head or anterior part of body; inter-radial membranes of pectoral fin hyaline; length of longest dorsal ray contained 3.6 to 4.4 times in standard length.

      4a. Teeth of upper jaw with 6 denticulations (rarely 5 or 7); teeth of lower jaw with 4 denticulations (including tip); caudal fin lunate, caudal concavity (see section on methods of measuring and counting) contained 3.7 to 6 times in standard length; body depth contained 1.9 to 2.3 in standard length; dorsal fin rays VIII, 27 to 31 (usually 28 to 30); anal fin rays III, 24 to 28 (usually 25 to 27) .... *Ctenochaetus striatus* (Quoy & Gaimard).

      4b. Teeth of upper jaw with 5 denticulations; teeth of lower jaw with

3 denticulations (including tip); caudal fin moderately concave, caudal concavity contained 5.7 to 10 times in standard length; body depth contained 1.7 to 2.0 in standard length; dorsal fin rays VIII, 25 to 28 (usually 26 or 27); anal fin rays III, 21 to 25 (usually 23 or 24)........ *Ctenochaetus strigosus* (Bennett).

3b. Teeth of upper jaw with 4 denticulations on lateral edge of their distal expanded ends; body without stripes, when alive speckled with numerous bright blue spots which may or may not persist as pale spots in preserved specimens; inter-radial membranes of pectoral fin dark brown; length of longest dorsal ray contained about 5.2 times in standard length...... *Ctenochaetus cyanoguttatus,* sp. nov.

2b. Teeth of upper jaw with 3 denticulations (including tip) on lateral edge of their distal expanded ends.

5a. Ratio of number of teeth in lower jaw to number in upper jaw about 2:1; caudal fin slightly emarginate, caudal concavity contained 18 to 40 times in standard length; longest dorsal ray contained 4 to 5 times in standard length; inner surfaces of lips plicate, margins crenulate: distance from base of upper lip to distal end of upper teeth contained 3.1 to 3.7 times in head length; length of snout contained 3.6 to 3.9 in standard length......... *Ctenochaetus hawaiiensis,* sp. nov. (Plate II, Fig. 2)

5b. Ratio of number of teeth in lower jaw to number in upper jaw about 1.2:1; caudal fin lunate, caudal concavity contained 6 to 7 times in standard length; longest dorsal ray contained 5.5 to 6 times in standard length; inner surfaces and margins of lips smooth; distance from base of upper lip to distal end of upper teeth contained 4.5 to 5.3 times in head length; length of snout contained 4.1 to 4.8 in standard length.... *Ctenochaetus magnus,* sp. nov.

1b. A prominent blackish spot at base of last 3 to 7 rays of both the dorsal and anal fins, these spots extending narrowly on adjacent regions of caudal peduncle.

6a. Membranes of caudal fin and posterior parts of dorsal and anal fins pale; margins of lips papillate; enlarged distal curved portions of each tooth of upper jaw with lower half smooth and blade-like and upper half with 3 (rarely 2) lateral denticulations ... *Ctenochaetus tominiensis*, sp. nov.

6b. Membranes of caudal, dorsal, and anal fins dark brown; margins of lips smooth; enlarged distal curved portion of each tooth of upper jaw divided into 6 approximately equal lateral denticulations .... *Ctenochaetus binotatus,* sp. nov.

CTENOCHAETUS STRIATUS (Quoy & Gaimard)

Text-fig. 1 A; Plate I, D-F; Text-fig. 3 B-D

Acanthurus argenteus Quoy & Gaimard, Voy. *Uranie,* Zool.: 372, pl. 63, fig. 2. 1824 (Guam); Cuvier & Valenciennes, Hist. Nat. Poiss., **10**: 239. 1835.

Acanthurus striatus Quoy & Gaimard, Voy. *Uranie,* Zool.: 373, pl. 63, fig. 3. 1824 (type locality, Guam); Cuvier & Valenciennes, Hist. Nat. Poiss., **10**: 229. 1835 (not Hawaiian Is.); ?Günther, Cat. Fish. Brit. Mus., **3**: 334. 1861 (Borneo).

Acanthurus ctenodon Cuvier, Règne Animal., **2**: 224. 1829; Cuvier & Valenciennes, Hist. Nat. Poiss., **10**: 241, pl. 289, 1835 (Caroline Is. and New Guinea); Günther, Cat. Fish. Brit. Mus., **3**: 342. 1861 (Ceylon and East Indies); Bleeker, Ned. Tijdschr. Dierk., **1**: 156. 1863 (Halmahera); Playfair, Fishes of Zanzibar: 57. 1866 (Zanzibar) (as variety *a*); Day, Proc. Zool. Soc. London: 688. 1870 (Andaman Is.).

?*Acanthurus flavoguttatus* Kittlitz (not of Herre, 1936, or Fowler, 1944), Mus. Senckenb., **1**: 193, pl. 13, fig. 5. 1834 (Caroline Is.).

?*Acanthurus Ketlitzii* Cuvier & Valenciennes, Hist. Nat. Poiss., **10**: 222. 1835.

Ctenodon Cuvierii Swainson, Nat. Hist. Class. Monocard. Animals **2**: 256. 1839.

Acanthurus strigosus Cuvier & Valenciennes (not of Bennett), Hist. Nat. Poiss., **10**: 243. 1835 (New Guinea); Bleeker, Nat. Tijdschr. Ned. Indië, **4**: 264. 1853 (New Guinea, not Hawaiian Is.); *ibid.*, **6**: 102. 1854 (East Indies); ?Günther, Cat. Fish. Brit. Mus., **3**: 342. 1861 (New Guinea, not Hawaiian Is.); Kner, *Novara* Exped. Fische, **1**: 211. 1865-1867 (Tahiti); Günther, Journ. Mus. Godeffroy, **2** (3): 116, pl. 79. figs. B and C. 1873 (Indo-Pacific); Day, Fishes of India, **1**: 207, pl. 47, fig. 2. 1876 (Andaman Is.);—Fauna Brit. India, **2**: 143. 1889 (India); Hardenburg, De Tropische Natuur, **22**: 155, fig. 1. 1933.

Acronurus argenteus Günther (in part), Cat. Fish. Brit. Mus., **3**: 346. 1861 (Marianas).

Acanthurus (Ctenodon) ctenodon Klunzinger, Synops. Fische Rothen Meeres: 509. 1871 (Red Sea).

Acanthurus (Ctenodon) strigosus Klunzinger, Fische Rothen Meeres, **1**: 85. 1884 (Red Sea); Weber, *Siboga* Exped. Fische, **57**: 319. 1913 (Indo-Australian Arch.).

Ctenochaetus strigosus Seale, Occ. Pap. B. P. Bishop Mus., **1**: 109. 1901 (Guam); Fowler & Ball (in part), B. P. Bishop Mus. Bull., 26: 19. 1925 (Wake I., not Hawaiian Is. or Johnston I.); Herre, Philipp. Journ. Sci., **24**: 438, pl. 15, figs. 2 and 3. 1927 (Philippine Is.); Fowler (in part), Mem. B. P. Bishop Mus., **10**: 247. 1928 (Oceania, not Hawaiian Is.); Fowler & Bean (in part), Bull. U. S. Nat. Mus.,100, **8**: 200. 1929 (Philippine Is. and East Indies); Herre, Field Mus. Nat. Hist. Zool. Ser., **21**: 247. 1936 (Polynesia and East Indies); Fowler, Acad. Nat. Sci. Phila. Mon., 2: 76, 147, 173, 185, 202, 215. 1938 (Marquesas Is., Society Is. and Christmas I. in the Line Is.); Poll, Mus. Roy. Hist. Nat. Belgique, **18**: 11. 1942 (Society Is.); Aoyagi, Coral Fishes: 218, pl. 6, fig. 20 (teeth only). 1943 (Riu Kiu Is.); Schultz (in part), U. S. Nat. Mus. Bull., 180: 161. 1943 (Phoenix and Samoa Is.); Hiyama, Poisonous Fishes South Seas: 83, pl. 19, fig. 52. 1943 (Marshall Is.); Smith, Sea Fishes S. Africa: 240, pl. 33, fig. 614. 1949 (Natal); de Beaufort, Fishes Indo-Aust. Arch., **9**: 128, fig. 24. 1951 (Indo-Pacific, not Hawaiian Is.); Harry, Atoll Res. Bull., 18: 150. 1953 (Raroia, Tuamotus).

Ctenodon ctenodon Fowler, Journ. Acad. Nat. Sci. Phila., **12**: 545. 1904 (Sumatra).

Ctenochaetus striatus Jordon & Seale (in part), Bull. Bur. Fish., **25**: 355. 1906 (Oceania, not Hawaiian Is.); Seale, Occ. Pap. B. P. Bishop Mus., **4**: 67. 1906 (Society Is., Cook Is., New Hebrides, Austral Is. and Solomon Is.); Evermann & Seale, Bull. Bur. Fish., **26**: 97. 1907 (Zamboanga, P. I.); Kendall & Radcliffe, Mem. Mus. Comp. Zoöl., **35**: 145. 1912 (Manga Reva); ?Jordan, Tanaka & Snyder, Cat. Fishes Japan: 634. 1913 (Misaki and Sagami, Japan); Fowler & Bean, Proc. U. S. Nat. Mus., **62**: 57. 1922 (Zamboanga, P. I.); Fowler, Proc. Acad. Nat. Sci. Phila., **75**: 42. 1923 (Madagascar); Herre, Philipp. Journ. Sci., **34**: 437, pl. 13, fig. 2. 1927 (Philippine Is.);—Field Mus. Nat. Hist. Zool. Ser., **21**: 246. 1936 (Tuamotus and Moorea); Schultz & Woods, U. S. Nat. Mus. Bull., 202: 620, pl. 61, fig. A, pl. 62, figs. A and B. 1953 (Marshall and Mariana Is.).

Teuthis striatus Barnard, Ann. S. Afric. Mus., **21**: 780. 1927 (Natal).

?*Ctenochaetus ctenodon* Whitley, Journ. Pan-Pacific Res. Inst., **3**: 12. 1928 (Santa Cruz Is.); Whitley & Colefax, Proc. Linn. Soc. New S. Wales, **63**: 294. 1938 (Nauru).

Diagnosis.—No black spot at axil of both dorsal and anal fins; teeth of upper jaw with 6 denticulations, of lower jaw 4, on lateral edge of expanded tips; membranes of pectoral fin hyaline; caudal fin lunate, caudal concavity 3.7 to 6 in standard length; dorsal soft rays usually 28 to 30.

Description.—Dorsal rays VIII, 27 to 31; anal rays III, 24 to 28; pectoral rays 16 or 17; anterior gill rakers 27 to 36; posterior gill rakers 29 to 42; scales from gill opening to posterior end of caudal peduncle spine 104 to 122.

Body depth 1.9 to 2.3, snout 4.2 to 4.8, pelvic fin 3.3 to 3.7, eighth dorsal spine 4.9 to 5.8, longest dorsal ray 3.6 to 4.4, third anal spine 5.4 to 6.7, longest anal ray 4.4 to 5.2, caudal concavity 3.7 to 6, all in standard length.

Margins and inner surfaces of lips smooth. Upper teeth with lateral edge of distal expanded end with 6 (rarely 5 or 7) denticulations. Lower teeth with 4 lateral denticulations at end (a small fifth one is sometimes evident).

Color in alcohol dark brown with numerous pale lengthwise slightly irregular lines on body (which are often faded and difficult to see); median fins brown; traces of about 5 lengthwise bands may at times be seen in the soft dorsal and anal fins; pectoral fin with rays light brownish (except uppermost principal ray which is edged in dark brown) and membranes hyaline; pelvic fins brown; young specimens may show a small black spot at the base of the last few dorsal rays. Color of juveniles dark brown with 8 to 12 pale longitudinal stripes on the body about ⅓ as

Table 3. Counts of Gill Rakers from the First Gill Arch for the Species of *Ctenochaetus*

Species and locality	Anterior series of gill rakers																						
	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
striatus																							
Marshall, Mariana and Samoa Is.										1	1	3	5	4	4	3	1						
Philippine Is. and East Indies										3	5	6	3	1									
Egypt, Red Sea									1	2	1												
Mauritius											2	3	1	1									
strigosus																							
Hawaiian Is.										1	2	2	2	2	2								
Philippine Is.								2	1	1	1	1											
cyanoguttatus, sp. nov.																							
Gilbert and Phoenix Is.							1		1	1													
hawaiiensis, sp. nov.																							
Hawaii				2		2																	
magnus, sp. nov.																							
Malden, Jarvis, and Cocos I.									3	1													
tominiensis, sp. nov.																							
Celebes	1	3																					
binotatus, sp. nov.																							
Philippine Is.				1	2	1	2	2	2	1													
	Posterior series of gill rakers																						
striatus																							
Marshall, Mariana and Samoa Is.												1		1		2	3	4	4	4	2		1
Philippine Is. and East Indies										1		1	1	2	3	2	4	3	1				
Egypt, Red Sea										1	2		1										
Mauritius													1	2	1	2	1						
strigosus																							
Hawaiian Is.											1	4	4	2									
Philippine Is.									1	3	1	1											
cyanoguttatus, sp. nov.																							
Gilbert and Phoenix Is.															1	1		1					
hawaiiensis, sp. nov.																							
Hawaii						1		2	1														
magnus, sp. nov.																							
Malden, Jarvis, and Cocos I.																1	3						
tominiensis, sp. nov.																							
Celebes	4																						
binotatus, sp. nov.																							
Philippine Is.			1		4	1	3	2															

broad as intermediate brown areas, which angle slightly downward as they pass posteriorly. At a standard length from 50 to 65 mm. the number of pale lines is suddenly doubled by the appearance of thin whitish lines in the center of the brown intermediate areas; these narrow lines become as broad as the pale lines of the first set, and more lines are added above and below, especially above, until the adult number of about 30 to 40 is attained. The ones added above the original set tend to angle upwards.

Color in life dark olive brown with blue lengthwise lines on the body and small orange spots on the head and nuchal region; soft dorsal and anal fins with about 5 lengthwise dark bluish lines; pectoral fin yellowish.

Juvenile specimens from the Gilbert Islands of about 40 mm. length were observed with the first set of pale lines red in color, narrow light bluish lines in the intermediate brown areas, and red tips to the lobes of the caudal fin. It is this color pattern that Herre (1927) probably tried to show in his Figure 2 of Plate 13 and which led him into the mistaken and persistent contention that this juvenile form was a different species. The error is an easy one to make in view of the variability in length at which adult coloration and configuration are assumed.

One specimen in the acronurus stage (transparent with silvery abdomen) was secured by night lighting at anchorage at Sydney Island in the Phoenix Islands by personnel of the Pacific Oceanic Fishery Investigations. This specimen, USNM No. 163616 and 32 mm. in standard length, is shown in Plate I, D. It is interesting to note that there is already a change-over taking place from larval dentition to adult-type dentition even though there is no evidence of any other bodily transformation to adult form. This change in dentition may be seen in only a slightly more advanced state in the transforming specimen of Plate I, E, from which the three teeth in Text-fig. 3 B to D were drawn. These teeth were all taken from the upper jaw of this specimen and show early stages in the transformation of tooth form. The inward bending of the expanded tips, already apparent in C, can only be seen in a side view of the teeth. The tooth drawn in A of Text-fig. 3 was taken from the *strigosus* acronurus of Plate I, D. All of its teeth are essentially alike; there are about 18 in each jaw. Probably this specimen is in an earlier stage of development than the *striatus* acronurus of Plate I, D. It is suspected that the teeth of *striatus* younger than the latter will bear 3 denticulations like the *strigosus* acronurus. The *striatus* acronurus has about 18 upper teeth and 16 lower teeth with more apparent just beneath the gums at the ends of the jaws. The lateral teeth are more adult-like in form than more medially-located teeth. The most striking thing about the dentition was the finding, upon dissection, of good-sized adult-type teeth imbedded in the soft tissue within the bones of the jaws. Five were found from one side of the upper jaw just above the upper teeth and six from one side of the lower jaw just below the lower teeth. Only the most medial of these imbedded teeth showed a departure from the *Ctenochaetus* pattern, for not all of the denticulations of this tooth were restricted to the lateral side. Subsequent dissection of the premaxillary and dentary bones of juvenile and adult specimens of *C. striatus* and other *Ctenochaetus* of all sizes showed these teeth to be present, in greater number and larger size in larger specimens, and it is believed that they function as replacement teeth. Specimens of species of *Acanthurus,* including acronurus and postacronurus forms, were examined, and adult-type teeth characteristic of this genus were also found imbedded in the bones of the jaws.

Remarks.—*C. striatus* is an exceedingly abundant and widespread species, probably occuring in the entire tropical Indo-Pacific region except the Hawaiian Islands. Jordan, Tanaka & Snyder (1913) record what is probably this species from Japan. J. L. B. Smith in a letter states that it appears to be the most abundant acanthurid on the reefs of tropical east Africa. At Onotoa Atoll in the Gilbert Islands, after two months of collecting, I found it was the dominant fish on a weight basis among all the reef fishes taken. It was very common on the benched reef slope (Cloud, 1952) of the windward reef of the atoll and about coral heads in the lagoon.

In the Red Sea *striatus* seems to have a lower gill raker count (Table 3) and also a greater percentage of specimens with 17 pectoral rays than 16 (Table 2). More material is needed from the Indian Ocean and Arabian Sea to clarify these and other differences.

Better established is the demarcation on the basis of dorsal and anal fin ray counts (Table 1) between populations in the Philippines and East Indies and the rest of Oceania. Also from the examination of fin ray counts, southeast Oceania (i.e., Society Islands and Tuamotus) may represent a differentiated population.

The largest specimen seen by me was 195 mm. in standard length. It was taken in the Philippines.

Taxonomic Discussion. — In all probability *Acanthurus argenteus* Quoy & Gaimard is a transforming *Ctenochaetus striatus.* These authors suspected that it was the young of some species they had not collected, but the nature of the striped color pattern and the high fin ray counts leave little doubt that it is the same as *striatus*. I retain the name *striatus* because it has been commonly used, whereas *argenteus* has been recognized as a name applying to an immediate postacronurus form (the name referring to the silvery coloration of the abdomen) and has never been applied to any adult surgeon fish.

The consideration of *Acanthurus flavoguttatus* Kittlitz (*A. Ketlitzii* Cuvier & Valenciennes) as a synonym of *C. striatus* is based on the Kittlitz figure which is greenish with yellow spots on the head and yellow lines on the body. Lack of reference to dentition and the peculiar fin ray counts account for the uncertainty in my decision. The type of *flavoguttatus* was not located.

Acanthurus ctenodon Cuvier & Valenciennes was referred to synonymy by Kner (1865) and by Günther (1873).

Much confusion has resulted from the frequent use of the name *strigosus* for the species *striatus*. This seems to stem from Günther (1873) who considered *striatus* the young of *strigosus* and in the overlooking by Gill (1884) of the Quoy & Gaimard species altogether in his erecting of the genus *Ctenochaetus*. Jordan & Evermann (1905) perpetuated the error by copying Günther's plate of *striatus* and using it to represent the common Hawaiian species which, in reality, is *strigosus*. Fowler (1928) did not help by referring *striatus* to the synonymy of *Acanthurus lineatus*.

Herre's (1927) separation of *strigosus* and *striatus* was based on specimens not exceeding 60 mm. in length and is erroneous.

CTENOCHAETUS STRIGOSUS (Bennett)

Plate II, Fig. 1; Text-fig. 1 B; Plate I, A-C; Text-fig. 3 A

Acanthurus strigosus Bennett, Zool. Journ., **4**: 41. 1828 (type locality, Hawaiian Is.); Cuvier & Valenciennes (in part?), Hist. Nat. Poiss., **10**: 243. 1835 (Hawaiian Is., probably not New Guinea); Günther (in part?), Cat. Fish. Brit. Mus. **3**: 342. 1861 (Hawaiian Is., probably not New Guinea).

Acanthurus (*Etenodon*) *strigosus* Steindachner, Denkschr. Akad. Wiss., **70**: 495. 1901 (Honolulu).

Ctenochaetus strigosus Jenkins, Bull. U. S. Fish. Comm., **22**: 480. 1903 (Honolulu); Snyder, Bull. U. S. Fish. Comm., **22**: 534. 1904 (Honolulu); Fowler & Ball (in part), B. P. Bishop Mus. Bull., 26: 19. 1925 (Laysan, French Frigate Shoals and Johnston I., but not Wake I.); Fowler (in part), Mem. B. P. Bishop Mus., **10**: 274. 1928 (only Hawaiian Is.); Fowler & Bean (in part), U. S. Nat. Mus. Bull., 100, **8**: 200. 1929 (Philippines and East Indies); Fowler, Mem. B. P. Bishop Mus., **11**: 344. 1931 (Honolulu);—Acad. Nat. Sci. Phila. Mon., 2: 233 (only). 1938 (Honolulu);—Proc. Acad. Nat. Sci. Phila., **93**: 257. 1941 (Honolulu); Whitley, Proc. Roy. Soc. New S. Wales: 23. 1954 (Great Barrier Reef, Australia).

Ctenochaetus striatus Jordan & Evermann, Bull. U. S. Fish. Comm., **23**: 398, (Fig. 174 after Günther, not *strigosus*), 1905 (Hawaiian Is.); Jordan & Jordan, Mem. Carnegie Mus., **10**: 66. 1922 (Hawaiian Is.).

Ctenochaetus flavicauda Fowler, Acad. Nat. Sci. Phila. Mon., 2: 104, pl. 10, fig. 24. 1938 (Takaroa, Tuamotus);—Mem. B. P. Bishop Mus., **12**: 104. 1949 (Takaroa, Tuamotus).

Ctenochaetus sp. Harry, Atoll Res. Bull., **18**: 151. 1953 (Raroia, Tuamotus).

Diagnosis.—No black spot at axil of dorsal or anal fin; teeth of upper jaw with 5 denticulations, of lower jaw 3, on lateral edge of expanded tips; membranes of pectoral fin hyaline; caudal fin moderately concave, caudal concavity 5.7 to 10 in standard length; dorsal soft rays usually 26 or 27.

Description.—Dorsal rays VIII, 25 to 28; anal rays III, 21 to 25; pectoral rays 16 (rarely 15); anterior gill rakers 27 to 34; posterior gill rakers 28 to 33; scales from gill opening to posterior end of caudal peduncle spine 85 to 96.

Body depth 1.7 to 2, snout 4.3 to 4.8, pelvic fin 3.1 to 3.4, eighth dorsal spine 4.8 to 5.5, longest dorsal ray 3.8 to 4.2, third anal spine 5.3 to 6.5, longest anal ray 4.4 to 4.7, caudal concavity 6 to 10, all in standard length.

Margins and inner surfaces of lips smooth; upper teeth with 5 denticulations (occasional teeth from Philippine specimens will show tiny 6th denticulation); lower teeth with 3 denticulations (including tip).

Color in alcohol brown with about 35 narrow pale bluish longitudinal lines (about ¼ as broad as the alternate brown bands) on the body which angle upwards on the basal part of the dorsal fin and downwards on the basal part of the anal; small pale spots on the head (and anteriorly on the body in Philippine specimens); a pale ring, broader posteriorly, around the eye in Hawaiian and Tuamotu specimens, restricted to the posterior edge of the eye in Johnston Island material, and absent in Philippine specimens; median fins brown (except caudal fin of Tuamotu specimens which is abruptly pale, white in life); pectoral fin pale except edge of uppermost principal ray which is almost black; pelvic fins brown.

Color in life from a 35 mm. kodachrome transparency of a Hawaiian specimen brown with narrow pale blue longitudinal lines on the body and basally on dorsal and anal fins; purplish region on chin; blue spots on head; yellow ring around eye; caudal fin brown; pectoral fin rays brownish, membranes orange-yellow; pelvic fins brown.

Hawaiian specimens in life show considerable variation in ground color. Some, especially in a light-colored environment (as areas of high coral cover), become a light tan in color. Others may be dark brown. The ground color of the species at Raroia, Tuamotus, was observed by Harry (1953) to be black.

Remarks.—Along with the color differences noted above, and meristic data, differences in the shape of the caudal fin may be seen among the specimens from the Philippines and East Indies, Hawaiian Islands, Johnston Island, Tuamotus and Mauritius which might form the basis for the recognition of subspecies when more material is available and the range of the species more completely known. The single specimen from Mauritius has the least concave caudal fin, the caudal concavity being contained in the standard length about 20 times. The caudal concavity of specimens from the Philippines and the Hawaiian Islands is 7 to 10. Johnston Island specimens have a caudal concavity which ranges from 5.7 to 9 in the standard length; Tuamotu specimens have the most lunate caudal fins, the caudal concavity contained about 5.7 times in the standard length.

Harry (1953) reported acute pain and swelling in the hand and arm when cut on the hand by the caudal spine of this species in Raroia; the pain did not subside until the second day and persisted for a week. He added that the only other surgeon fish he encountered producing such effects was *C. striatus* (recorded as *strigosus*), though pain from this species lasted only 3 to 4 hours and was not so intense. I tested the poisonous qualities of the caudal spine of Hawaiian *strigosus* by gingerly inserting the tip of the spine into my palm; a stinging sensation was soon experienced, and the experiment was carried no further.

This species is extremely abundant in the Hawaiian Islands where it is known by the local name Kole. Elsewhere, except perhaps Johnston Island, it is not at all common. Only 13 specimens from the Philippines, Moluccas and Celebes were found at the U. S. National Museum among the vast collections made by the *Albatross* Philippine Expedition (1907-1910); only four are known from the Tuamotus, and one from Mauritius. The single specimen from the Great Barrier Reef was identified by Whitley with the aid of a manuscript key such as appears in this paper and was recorded from Australia by him (1954).

Although more collecting in the Indo-Pacific region may reveal new localities for *strigosus*, it is believed that it is not in continuous distribution throughout its range. The differentiation which has taken place in five of its known localities supports this contention. The great abundance of this species in Hawaii stands in sharp contrast to its apparent absence from much of the Indo-Pacific and its scarcity in the few areas where it does occur. This may be associated with the absence of *striatus* from the Hawaiian Islands.

The acronurus specimen (Plate I, A), U.S.N.M. 118040 and 27 mm. in standard length, was taken at night from the steamer *Albatross* at the surface at Diamond Head Light, Oahu, Hawaiian Islands, on May 6, 1902. The transforming specimen of Plate I, B (University of Hawaii No. 1877) was collected by W. A. Gosline on the reef at Diamond Head, Oahu, May 16, 1950. It is 28 mm. in standard length. The recently transformed juvenile (Plate I, C), U.S.N.M. 167199, was taken by the author at a depth of 40 feet, Waikiki, Oahu, on June 4, 1952. As no small juveniles have been seen in tidepools or very shallow water, it is suspected that the acronurus transforms to the juvenile stage at a moderate depth on the reef. Postacronurus and juvenile *striatus*, on the other hand, occur in immense numbers in tidepools and protected shallow-water areas.

The largest specimen of *strigosus* seen by me, 139 mm. in standard length, was collected by the *Albatross* Philippine Expedition at Luzon.

The food habits of this species are discussed in the general section on the genus.

CTENOCHAETUS CYANOGUTTATUS, sp. nov.

Text-fig. 1 C

?*Acanthurus guttatus* Kittlitz (not of Bloch & Schneider), Mus. Senckenb., **1**: 193, pl. 13, fig. 4. 1834 (Luganor I.).

?*Acanthurus marginatus* Cuvier & Valenciennes, Hist. Nat. Poiss., **10**: 221. 1935 (new name for *Acanthurus guttatus* Kittlitz); Günther, Cat. Fish. Brit. Mus., **3**: 333.1861 (Luganor).

?*Acanthurus ctenodon* Var. *b* Playfair, Fishes of Zanzibar, 57. 1866. (Zanzibar).

Ctenochaetus strigosus Snodgrass & Heller, Proc. Washington Acad. Sci., **6**: 402. 1905 (Cocos I., Costa Rica); Schultz (in part), U. S. Nat. Mus. Bull., 180: 161. 1943 (Hull I.).

Ctenochaetus sp. Hiyama, Poisonous Fishes South Seas: 92, pl. 19, fig. 53. 1943 (Marshall Is.).

Holotype.—U.S.N.M. No. 167178, Aunteuma Island, Onotoa Atoll, Gilbert Islands, lee side, depth of water about 5 feet in poorly-defined surge channel region, August 1, 1951, spear, John E. Randall, 170.5 mm. in standard length.

Paratypes.—U.S.N.M. No. 167179, same data as holotype except date, August 11, 1951, 166 mm.; U.S.N.M. No. 115152, Hull Island, reef, July 13, 1939, Leonard P. Schultz, 157 mm.; Stanford Mus. No. 12280, Cocos Island, Costa Rica, Hopkins-Stanford Galapagos Expedition, 1898-1899. (Precise proportional measurements and scale and gill raker counts were not made on the Cocos Island specimen).

Diagnosis.—No black spot at axil of dorsal or anal fin; teeth of upper jaw with 4 denticulations, of lower jaw 3, on lateral edge of expanded tips; membranes of pectoral fin dark brown; caudal concavity 5.8 to 6.2 in standard length; dorsal soft rays 27 or 28.

Description.—Dorsal rays VIII, 27 (27 to 28); anal rays III, 25; pectoral rays 17 (16 to 17); anterior gill rakers 28 (26 to 29); posterior gill rakers 35 (34 to 37); scales from gill opening to posterior end of caudal peduncle spine 95 (94-104); upper teeth 44, lower teeth 60.

Depth of body 1.85 (1.94 to 1.95), length of head 3.48 (3.27 to 3.61), length of snout 4.34 (4.36 to 4.74), length of pectoral fin 3.10 (3.02 to 3.13), length of pelvic fin 2.94 (2.91), length of 8th dorsal spine 5.09 (5.24 to 5.27), length of longest dorsal ray 5.14 (4.62 to 4.89), length of third anal spine 5.89 (5.81 to 6.15), length of longest anal ray 5.01 (5.42 to 5.44), caudal concavity 6.20 (5.81 to 5.93), all in standard length. Greatest diameter of eye 4.41 (4.26 to 4.40), width of inter-orbital space 3.06 (2.87 to 3.1), least depth of caudal peduncle 2.27 (2.19 to 2.34), length of caudal peduncle spine 2.90 (2.42 to 2.67), distance from base of upper lip to distal ends of upper teeth 5.1 (4.9 to 5.1), all in length of head.

Inner surfaces of lips and margin of upper lip smooth; margin of lower lip, especially posteriorly, papillate. Upper teeth with 4 (rarely 3) denticulations (the one at the tip being longest); lower teeth with 3 denticulations (counting tip).

Color in alcohol dark brown with numerous small pale spots on the body and pectoral fin (these spots are faint and difficult to see even in freshly preserved fish); all fins brown; dorsal and anal fins with about 9 or 10 longitudinal dark brown lines (fewer anteriorly in these fins).

Color in life dark brown with head, body, and pectoral fins profusely covered with small bright blue spots, hence the name, *cyanoguttatus*.

Remarks.—This species was observed by me in its natural habitat on two occasions at Onotoa, Gilbert Islands. It was seen in small rapidly-moving schools in moderately rough water in broad shallow surge channels on the lee side of the atoll. It was a mode of life similar to that of *Acanthurus guttatus*, the latter species schooling in the rougher water of sharply-defined surge channels on the windward side of the atoll. The spotting of the body of both these species might be associated with the masses of small swirling air bubbles in the water that characterize the surf zone where they live.

Taxonomic Discussion.—*Acanthurus guttatus* Kittlitz was a brown fish with blue spots and 8 dorsal spines. Cuvier & Valenciennes, realizing that this could not be the *A. guttatus* of Bloch & Schneider, gave the species the name *marginatus*. It is possible that this species was *Ctenochaetus cyanoguttatus*. But no mention was made of the important item of dentition, although the teeth in Kittlitz' figure are drawn fairly long. The count of dorsal spines cannot be considered too diagnostic, for species of *Acanthurus* have been recorded with 8 instead of 9 dorsal spines because of the inconspicuous nature of the first spine. Even the blue spots are not unique, for adult *Acanthurus nigroris* Cuvier & Valenciennes (=*Hepatus atramentatus* Jordan & Evermann) at Wake Island had the usual blue lines broken up into spots, which gave this species an appearance much like *C. cyanoguttatus*. In view of this, and the fact that the Kittlitz specimen has not been located, describing the species as new seems in order. The Kittlitz specimen is not in the Senckenberg Museum. Günther (1861) stated that the type of *Acanthurus pyroferus* described by Kittlitz from the same publication was in the old St. Petersburg Museum. The specimen of *A. marginatus* may be there; I have been unable to complete correspondence on the matter.

The Cocos Island specimen of Snodgrass & Heller (1904) is referable to this species, although there is no record of the color in life and the spots which were probably present have now faded. G. S. Myers, who kindly loaned the specimen (SU 12280) to me, states that only one other of the four specimens collected from Cocos is now located at the Natural History Museum, Stanford University.

CTENOCHAETUS HAWAIIENSIS, sp. nov.

Plate II, Fig. 2; Text-fig. 1 D

Ctenochaetus hawaiiensis Brock, Journ. Wildlife Man., **18**: 307. 1954 (nomen nudum; name used by Brock from a personal communication before species published).

Holotype.—U.S.N.M. No. 167180, entrance to Keauhou Bay, Hawaii, Hawaiian Islands, depth of water about 12 feet, February 8, 1952, spear, John E. Randall, 197.5 mm. in standard length.

Paratypes.—U.S.N.M. No. 167181, Keahole Point, Hawaii, Hawaiian Islands, depth of water 40 feet, June 18, 1953, spear, Vernon E. Brock, 2 specimens, 204 and 209 mm.; Standford Mus. No. 47661, same data as other paratypes, 202.5 mm.

Diagnosis.—No black spot at axil of dorsal or anal fin; teeth of upper and lower jaws with 3 denticulations on lateral edge of expanded tips; membranes of pectoral fin dark brown; twice as many teeth in lower jaw as upper; caudal fin slightly emarginate to nearly truncate; dorsal soft rays 27 or 28.

Description.—Dorsal rays VIII, 28 (27 to 28); anal rays III, 25 (25 to 26); pectoral rays 16; anterior gill rakers 25 (23 to 25); posterior gill rakers 28 (25 to 27); scales from gill opening to posterior end of caudal peduncle spine 139 (115 to 131); upper teeth 26; lower teeth 56.

Depth of body 1.81 (1.82 to 1.84), length of head 3.00 (3.27 to 3.32), length of snout 3.66 (3.81 to 3.92), length of pectoral fin 3.05 (3.07 to 3.21), length of pelvic fin 3.87 (3.61 to 3.78), length of eighth dorsal spine 4.60 (4.50 to 4.80), length of longest dorsal ray 4.12 (4.18 to 4.21), length of third anal spine 6.49 (5.96 to 6.97), length of longest anal ray 4.49 (4.50 to 4.86), caudal concavity 18.8 (15.0 to 40.8), all in standard length. Greatest diameter of eye 4.86 (4.39 to 4.85), width of inter-orbital space 3.30 (2.97 to 3.14), least depth of caudal peduncle 2.30 (2.17 to 2.38), length of caudal peduncle spine 3.14 (2.87 to 3.75), distance from base of upper lip to distal ends of upper teeth 3.66 (3.15 to 3.64), all in length of head. The last-mentioned measurement, which might also be loosely termed the height of upper lip, is greater in this species than any other in the genus (this distance in other species is contained in the head length 4.5 to 6.6 times).

Margins of lips finely crenulate; distal one-fourth of inner surfaces of lips plicate, the ridges running perpendicular to the margin. Upper and lower teeth with 3 denticulations (including tips); lower teeth about twice as numerous as upper teeth.

Color in alcohol very dark brown with many narrow pale longitudinal lines faintly visible on head and body; (these lines tend to be less irregular than those on other species; the lines on the head are somewhat diagonal); all fins dark brown.

Color in life dark olive brown (appearing almost black underwater) with fine yellowish-gray lengthwise lines on the head and body.

Remarks.—This species is thus far known only from the island of Hawaii in the Hawaiian Islands, where it is common; it is named for this locality. Fishermen have told me that it is seen rarely at the island of Maui. It certainly does not seem to be present in the waters around the island of Oahu, which are well-collected.

I have observed *hawaiiensis* underwater on only four occasions, three times as a solitary fish and once as a group of three fish. Vernon E. Brock, Division of Fish and Game, Territory of Hawaii, has told me that he has observed the species in schools.

A smaller specimen (estimated 100 mm. in standard length), yellowish-brown in color, and possibly *hawaiiensis*, was sighted by me at a depth of 70 feet in Kealakekua Bay, Hawaii, but was not taken.

CTENOCHAETUS MAGNUS, sp. nov.

Text-fig. 1 E

Ctenochaetus strigosus Fowler (in part), B. P. Bishop Mus. Bull., 38: 20. 1927 (Jarvis I.).

Holotype.—U.S.N.M. No. 163614, Malden Island (4° 03′ S., 154° 59′ W.), January 27, 1951, spear, Herbert Mann and Joseph E. King, Pacific Oceanic Fishery Investigations, 225 mm. in standard length.

Paratypes.—Stanford Mus. No. 47662, same data as holotype, 219 mm.; B. P. Bishop Mus. No. 4308, Jarvis Island (0° 23′ S., 160° 02′ W.), August 15, 1924, Whippoorwill Expedition, 205.5 mm., U.S.N.M. No. 163659, Cocos Island, Costa Rica, December 28, 1952, Bruce W. Halstead and Norman C. Bunker, 209 mm.

Diagnois.—No black spot at axil of dorsal or anal fin; teeth of upper and lower jaws with 3 denticulations on lateral edge of expanded tips; membranes of pectoral fin dark brown; 1.2 times as many teeth in lower jaw as upper jaw; caudal concavity 6 to 7 in standard length; dorsal soft rays 26 or 27.

Description.—Dorsal rays VIII, 27 (26 to 28); anal rays III, 25 (24 to 25); pectoral rays 17 (16 to 17); anterior gill rakers 28 (28 to 29); posterior gill rakers 36 (35 to 36); scales from gill opening to posterior end of caudal peduncle spine 159 (149 to 164); upper teeth 59; lower teeth 68.

Depth of body 2.14 (2.02 to 2.13), length of head 3.14 (3.32 to 3.48), length of snout 4.60 (4.18 to 4.76), length of pectoral fin 3.13 (3.05 to 3.17); length of pelvic fin 2.87 (2.98 to 3.16), length of eighth dorsal spine 5.00 (5.76 to 5.97), length of longest dorsal ray 5.92 (5.54 to 5.63), length of third anal spine 6.52 (6.26 to

6.74), length of longest anal ray 6.00 (5.02 to 6.44), caudal concavity 5.63 (6.04 to 7.45), all in standard length. Greatest diameter of eye 5.07 (4.50 to 4.88), width of inter-orbital space 2.87 (3.00 to 3.07), least depth of caudal peduncle 2.27 (2.22 to 2.47), length of caudal peduncle spine 2.36 (2.33 to 2.57), distance from base of upper lip to distal ends of upper teeth 5.28 (4.5 to 5.3), all in length of head.

Margins and inner surfaces of lips smooth. Upper and lower teeth with 3 denticulations (including tips).

In alcohol the color of this species is uniform dark brown. The only record of color in life which I have is that given by Fowler (1927) for the Jarvis Island specimen. He states that the body including the pectorals was covered all over with fine blue-gray dots.

Remarks.—Thus far *Ctenochaetus striatus* (and *C. strigosus* as well) is not known from Malden, Jarvis and Cocos Islands, in spite of its common occurrence elsewhere in the tropical Pacific. These islands are the sole known localities for *C. magnus.*

Assuming that *Ctenochaetus* is Indo-Pacific in origin, which seems reasonable in view of the distribution of the species of this genus and the Acanthuridae in general, one must explain how *magnus* (and *cyanoguttatus*) crossed the East Pacific barrier (Ekman, 1953). Malden Island and especially Jarvis Island are near the counter-equatorial current which could conceivably carry fish larvae the great distance to Cocos Island (possibly via the Galapagos Islands). Herre (1940) discusses this mode of transport.

This species is named *magnus* in reference to its large size.

CTENOCHAETUS TOMINIENSIS, sp. nov.

Text-fig. 1 F

Ctenochaetus strigosus Fowler & Bean (in part), U. S. Nat. Mus. Bull., 100, **8**: 200. 1929 (Gulf of Tomini, Celebes, only).

Holotype.—U.S.N.M. No. 136112, Sadaa Island, Gulf of Tomini, Celebes, November 17, 1909, dynamite, *Albatross* Philippine Expedition, 98 mm. in standard length.

Paratypes.—U.S.N.M. No. 136093, Buka Island, Gulf of Tomini, Celebes, November 20, 1909, dynamite, *Albatross* Philippine Expedition, 4 specimens, 74 to 100 mm.; Stanford Mus. No. 47663, same data as other paratypes, 87 mm.

Diagnosis.—A black spot at axil of both the dorsal and the anal fins; teeth of upper jaw with 3 denticulations on upper lateral edge of expanded tips; teeth of lower jaw with 3 denticulations; membranes of caudal fin, posterior parts of dorsal and anal fins and pectoral fins pale; margins of lips papillate; dorsal soft rays 24 or 25.

Description.—Dorsal rays VIII, 24 (25); anal rays III, 22 (22 to 23); pectoral rays 15, 16 (15 to 16); anterior gill rakers 21 (20 to 21); posterior gill rakers 20 (20); scales from gill opening to posterior end of caudal peduncle spine 91 (83 to 86); upper teeth 33; lower teeth 32.

Depth of body 2.04 (1.80 to 2.00), length of head 3.49 (3.22 to 3.37), length of snout 4.56 (4.40 to 4.65), length of pectoral fin 3.06 (2.69 to 3.03), length of pelvic fin 3.50 (3.28 to 3.59), length of eighth dorsal spine 6.12 (5.33 to 6.06), length of longest dorsal ray 3.50 (3.57 to 4.40), length of third anal spine 6.95 (5.87 to 6.90), length of longest anal ray 3.92 (4.00 to 4.11), caudal concavity 5.03 (4.35 to 6.52), all in standard length. Greatest diameter of eye 3.37 (3.17 to 3.53), width of inter-orbital space 2.92 (2.81 to 3.09), least depth of caudal peduncle 2.29 (2.23 to 2.44), length of caudal peduncle spine 2.55 (2.50 to 3.25), distance from base of upper lip to distal ends of upper teeth 6.20 (6.00 to 6.10), all in length of head.

Margins of lips papillate or crenulate, inner surfaces smooth. Upper teeth with distal half of the expanded ends smooth and blade-like and basal half divided into 3 (rarely 2) lateral denticulations; lower teeth with 3 (occasionally 4) denticulations (including tip).

Color in alcohol brown with a jet black spot at the base of the last few dorsal and anal fin rays, these spots extending slightly on to the caudal peduncle; caudal fin pale yellowish, gradually becoming brown basally, outer portions of the soft dorsal and anal fins pale yellowish, especially posteriorly, basally brown like body; outer portion of the brown part of these fins with about 3 to 5 narrow pale horizontal bands (difficult to see on some specimens) which become confluent with the pale distal region of the fins as they pass posteriorly; pectoral fins with rays brownish, membranes pale; pelvic fins brown, a little darker terminally.

The following color note from fresh specimens was taken from Fowler & Bean (1929); it was associated with this species by means of *Albatross* field numbers. "Brownish, dark in life, spotting of side of head indistinct, lower part slightly paler. Dorsal olive, with 5 or 6 bars, beginning as darker olive and on soft fin become cadmium or orange, fuse on fin posteriorly and terminally to form entire color; extreme fin edged narrowly black above; black blotch at axil. Anal like dorsal. Caudal fades whitish. Ventral blackish terminally, membranes hyaline and scattered small, orange, basal spots, rays probably black in life."

Remarks.—Named *tominiensis* for the Gulf of Tomini, Celebes.

CTENOCHAETUS BINOTATUS, sp. nov.

Text-fig. 1 G

Ctenochaetus strigosus Fowler & Bean (in part), U. S. Nat. Mus. Bull., 100, **8**: 200. 1929 (Philippine Is. and East Indies).

Holotype.—U.S.N.M. No. 136125, Pagapas Bay, Luzon, Philippine Islands, February 20, 1909, dynamite, *Albatross* Philippine Expedition, 111 mm. in standard length.

Paratypes.—U.S.N.M. Nos. 136061, 136064, 136073, 136075 to 136080, 136083, 136095, 136099, 136102 to 136105, 136109, 136111, 136114, 136116, 136119, Philippines and Moluccas, January 20, 1908, to November 24, 1909, all taken with use of dynamite except one specimen from market at Cebu Island, *Albatross* Philippine Expedition, 27 specimens, 79 to 141 mm.; Stanford Mus. No. 27174, Jolo, Philippines, August 15, 1931, A. W. Herre, 2 specimens, 106 and 121 mm.

Diagnosis.—A black spot at axil of both the dorsal and anal fins; teeth of upper jaw with 6 denticulations, of lower jaw 3, on lateral edge of expanded tips; membranes of caudal fin and dorsal and anal fins dark brown; membranes of pectoral fin hyaline; margins of lips smooth; dorsal soft rays 24 to 27 (mostly 26).

Description.—Dorsal rays VIII, 25 (24 to 27), anal rays III, 23 (22 to 25), pectoral rays 16 (15 to 16), anterior gill rakers 29 (23 to 29), posterior gill rakers 24 (22 to 27), scales from gill opening to posterior end of caudal peduncle spine 102 (93 to 100), upper teeth 39, lower teeth 42.

Depth of body 1.93 (1.88 to 2.03), length of head 3.47 (3.29 to 3.79), length of snout 4.74 (4.77 to 5.47), length of pectoral fin 2.77 (2.86 to 3.10), length of pelvic fin 3.47 (3.44 to 3.78), length of eighth dorsal spine 5.84 (5.64 to 6.15), length of longest dorsal ray 3.77 (3.61 to 4.58), length of third anal spine 5.84 (5.81 to 6.21), length of longest anal ray 4.21 (4.20 to 4.74), caudal concavity 4.27 (4.51 to 6.15), all in standard length. Greatest diameter of eye 3.41 (3.12 to 3.91), width of inter-orbital space 2.91 (2.60 to 3.16), least depth of caudal peduncle 2.19 (1.97 to 2.32), length of caudal peduncle spine 2.74 (2.43 to 3.60), distance from base of upper lip to distal ends of upper teeth 6.4 (5.5 to 6.6), all in length of head.

Margins and inner surfaces of lips smooth. Upper teeth with expanded distal part divided into 6 approximately equal lateral denticulations; lower teeth with 3 denticulations (counting tip).

Color in alcohol brown with pale lengthwise lines on the body, (much as in *strigosus* except these lines are about twice as broad as the alternate darker brown lines); a prominent black spot at the base of the last few dorsal and anal fin rays, these spots extending narrowly on to the caudal peduncle; median fins brown; pectoral rays light brownish, the membranes hyaline; margin of uppermost principal pectoral ray dark brown; pelvic fins yellowish, lateral edges and ends of rays brownish.

There is no positive record of the color in life. Fowler & Bean (1929) give a color note for three specimens, one of which was identified as the type of *binotatus* by virtue of the *Albatross* field number; however, one of the remaining specimens (the other was not located) proved to be *C. striatus*. The color description is as follows: "Fine stripes of light bluish on the shoulder at and below the pectoral base and body posteriorly greenish. On dorsal 5 or 6 densely greenish stripes, similarly on anal. First pectoral ray very dark, center of fin yellow. Ventrals like body. Some examples with fine lines on body very deep violet." Both the type of *binotatus* and the one specimen of *striatus* faintly show in the preserved state the narrow lengthwise lines posteriorly on the body as well as the shoulder and pectoral region. It seems odd that the posterior markings would not be apparent in life.

Remarks.—Named *binotatus* for the two black marks, one at the axil of the soft dorsal fin and the other at the axil of the anal fin.

A recently-transformed 35 mm. specimen of *Ctenochaetus* (U.S.N.M. No. 167177), collected in the lagoon at Onotoa Atoll, Gilbert Islands, by the author was noted to have a brilliant yellow caudal peduncle and caudal fin and stood out in sharp contrast to the young of *C. striatus* picked up at the same time. Examination of the preserved specimen some months later revealed the last few rays of the soft dorsal and anal fins to be colorless and a small spot to be present in each fin at the base of these rays; small dark brown spots were observed on the head and anteriorly on the body. Meristic data are as follows: D VIII, 27; A III, 25; pectoral rays 15; anterior gill rakers 27; posterior gill rakers 27, upper teeth 22, lower teeth 22. The upper teeth bear 6 or 7 denticulations (usually 7) and the lower teeth 3 or 4 (mostly 4). Of the known species of *Ctenochaetus*, this specimen would best receive the label of *binotatus*; however, there are some obvious differences such as coloration and structure of the teeth. Since no specimens of *binotatus* below 79 mm. in standard length are available for comparison and none of any size from Gilbert Islands (if the species occurs there), the differences observed may be due to the juvenile nature of the specimen or the geographical separation of the Gilbert Islands from the Philippines and East Indies. It is certain that the specimen is not *Ctenochaetus flavicauda* Fowler, for the latter is a variant of C. *strigosus*, and probably had a white tail in life instead of a yellow one.

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[2] See synonymy for taxonomic references.

EXPLANATION OF THE PLATES

Plate I

Acronurus, postacronurus, and juvenile stages of *Ctenochaetus.* A to C. *strigosus.* D to F. *striatus.* Natural size.

Plate II

Fig. 1. *Ctenochaetus strigosus* (Bennett). 95 mm. specimen from the Hawaiian Islands drawn by Miss Marion Adachi.

Fig. 2. *Ctenochaetus hawaiiensis,* sp. nov. Drawing of holotype by Miss Marion Adachi.